

**Green Text is Proposed Changes**  
**Red Text is Additional Explanation**

## APPENDIX B

# DRAFT MEASUREMENT PROCEDURES FOR DFS EQUIPPED U-NII DEVICES

## Introduction

The purpose of this appendix is to define procedures for testing of the radar detection capability referred to as Dynamic Frequency Selection (DFS) of unlicensed U-NII equipment operating in the frequency bands 5250 MHz to 5350 MHz and 5470 MHz to 5725 MHz. These procedures will be used to test the efficacy of DFS as an interference mechanism as formulated by the International Telecommunication Union-Radiocommunications Sector (ITU-R) and documented in Recommendation ITU-R M.1652 and called for in the U-NII Notice of Proposed Rulemaking (NPRM).<sup>1</sup> A major source for the content of this document is the European Telecommunication Standards Institute (ETSI) draft EN 301 893 version 1.2.3.2, which is the approved final European conformance standard for 5GHz operation. Using ETSI EN 301 893 and its associated reference documents as baseline for developing this test plan does not infer that the United States confers with all of the standards, practices, procedures, and tolerances set within them.

**Atheros: EN 301 893 V1.2.3 was the final version published by ETSI. There are only typographical corrections between Versions 1.2.2 and 1.2.3.**

## Scope

The scope of this document includes an overview of DFS operational requirements, the detection and response criteria and methods of measuring compliance with these criteria. The methods include calibration and test procedures for conducted and radiated measurements. Conducted measurements are preferred over radiated measurements because they are more precise and contain less measurement errors. Equipment with an integral antenna may be equipped with a temporary antenna connector in order to facilitate the conducted tests. When the antenna can not be separated from the device and a radio frequency (RF) test port is not provided, radiated measurements may be performed.

General information about test sites and measurement techniques are assumed to be known and not covered here.

---

<sup>1</sup> *Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, Notice of Proposed Rulemaking, ET Docket No. 03-122, (released June 4, 2003) ("U-NII NPRM").

Procedures for equipment submission; certification and other regulatory aspects are not covered in this document.

## References

- [1] Draft New Recommendation ITU-R M.1652
- [2] Draft EN 301 893 ETSI (RLAN Radio Conformance Test standard)

## Definitions, symbols and abbreviations

### Definitions

For the purposes of the present document, following terms and definitions apply.

**5 GHz U-NII bands:** Frequency ranges: 5150 - 5250 MHz, 5250 - 5350 MHz, 5470 - 5725 MHz and 5725 – 5825 MHz.

**Association:** an active relationship between two wireless devices in which one device (referred to as “Master device” in this document) exercises certain control functions to which the other device (referred to as “Client device” in this document) has to respond.

**Burst:** a period during which radio waves are intentionally transmitted, preceded and succeeded by periods during which no intentional transmission is made.

**Channel:** amount of spectrum used by a single unlicensed U-NII device operating on one of the specified carrier frequencies

**Channel Availability Check Time:** the time during which a channel shall be checked for the presence of a radar signal with a level above the Interference Detection Threshold. No transmissions shall occur during this time.

**Channel Closing Transmission Time:** the aggregate duration of transmissions ~~of control information~~ by unlicensed U-NII devices during the Channel Move Time which starts upon detection of an interfering signal above the Interference Detection Threshold. The aggregate duration of all transmissions shall not count quiet periods in between transmissions.

**Atheros: The draft test procedure does not now (and should not in future) require deciphering contents of transmitted packets (i.e. data packets vs. control packet). The CCTT limit should apply equally and limit aggregate transmission of any type to the agreed limit. A radar does not care whether bits sent in an RLAN transmission are 'control' or 'data' packets.**

**Channel Move Time:** the time taken by an unlicensed U-NII device to cease all transmissions on the current channel upon detection of an interfering signal above the Interference Detection Threshold.

**Client Device:** an unlicensed U-NII device operating in Client mode.

**Client mode:** operating mode in which the transmissions of the unlicensed U-NII device are under control of the Master. An unlicensed U-NII device in Client mode is not able to initiate a network.

**In-Service Monitoring:** a mechanism to check a channel in use by the unlicensed U-NII device for the presence of a radar signal with a level above the Interference Detection Threshold.

**Interference Detection Threshold** is the level to be used by the DFS function to detect radar interference.

**Master Device:** an unlicensed U-NII device operating in Master mode.

**Master mode:** operating mode in which the unlicensed U-NII device has the capability to transmit without receiving an enabling signal. In this mode it is able to select a channel and initiate a network by sending enabling signals to other unlicensed U-NII devices. An unlicensed U-NII network always has at least one unlicensed device operating in Master mode.

**Simulated Radar burst:** a series of periodic radio wave pulses, separated by a period during which no pulses are transmitted.

## Symbols

For the purposes of the present document, the following symbols apply:

A	Measured power output (dBm)
B	Radar burst period
$Ch_f$	Channel free from radars
$Ch_r$	Channel occupied by a radar
D	Measured power density
E	Field strength
$E_o$	Reference field strength
$f_c$	Carrier frequency
G	Antenna gain (dBi)
L	Radar burst length
n	Number of channels
$P_H$	Calculated EIRP at highest power level
$P_L$	Calculated EIRP at lowest power level
PD	Calculated power density
R	Distance
$R_o$	Reference distance
S0	Signal power

T0	Time instant
T1	Time instant
T2	Time instant
T3	Time instant
W	Radar pulse width
x	Observed duty cycle

## Abbreviations

For the purposes of the present document, the following abbreviations apply:

DFS	Dynamic Frequency Selection
EMC	Electro-Magnetic Compatibility
EIRP	Equivalent Isotropic Radiated Power
LV	Low Voltage
PRF	Pulse Repetition Frequency
RE	Radio Equipment
UUT	Unit Under Test

## Technical Requirements for DFS in 5.25-5.35 and 5.47-5.725 GHz Bands

### DFS Overview

An unlicensed U-NII network shall employ a DFS function to:

- detect interference from other systems and to avoid co-channel operation with these systems, notably radar systems.
- provide on aggregate a uniform loading of the spectrum across all devices by selecting at startup, ~~at random~~, on one of the channels that the unlicensed device is capable of operating. This applies in the 5.25-5.35 and 5.47-5.725 GHz bands

Atheros: "Random" was explicitly kept out of the ETSI test spec and should not be part of FCC rules.

"Uniform" use of available channels does not require a "random" channel selection mechanism, although some implementations may use such a method.

Atheros: No new requirements (i.e. uniform loading) should apply to the existing 5.15-5.25 and 5.725 and higher bands.

The DFS function as described in the present document is not tested for its ability to detect frequency agile radars. Within the context of the operation of the DFS function, an

unlicensed U-NII device shall operate in either Master mode or Client mode. Unlicensed devices operating in Client mode (Client device) can only operate in a network controlled by a unlicensed U-NII device operating in Master mode (Master device).

The operational behavior and individual DFS requirements that are associated with these modes are as follows:

### **Master Devices**

- a) The Master device shall use a Radar Interference Detection function in order to detect radar signals with a level above the *Interference Detection Threshold* in the frequency ranges 5250 – 5350 MHz and 5470 – 5725 MHz. Radar detection is not required in the frequency range 5150 – 5250 MHz or 5725 – 5825 MHz.
- b) The Master device initiates an unlicensed U-NII network by transmitting control signals that will enable other unlicensed U-NII devices to Associate (participate in a wireless network) with the Master device.
- c) Before initiating a network on a Channel, the master shall perform a *Channel Availability Check* for a certain duration (*Channel Availability Check Time*) to ensure that there is no radar operating on the Channel, using the Radar Interference Detection function described under a).
- d) During normal operation, the Master shall monitor the operating channel (*In-Service Monitoring*) to ensure that there is no radar operating on the channel, using the Radar Interference Detection function described under a).
- e) If the Master device has detected a radar signal, during In-Service Monitoring as described under d), the operating Channel of the unlicensed U-NII network is made unavailable. The Master shall instruct all Associated devices to stop transmitting on this Channel, which they shall do within the *Channel Move Time*. The Aggregate Transmissions during the *Channel Move Time* should be limited to the *Channel Closing Transmission Time*.
- f) A Master device shall not attempt to initiate a network on a Channel in the frequency range 5600-5650 MHz during a period defined as the *Non-Occupancy Period* after a radar has been detected in that Channel, regardless of the outcome of any In-Service Monitoring or Channel Availability Check procedures. The *Non-Occupancy Period* commences at the time the radar was detected in the Channel.

### **Client devices**

- a) An unlicensed U-NII Client device shall not transmit before having received an appropriate enabling signal from a Master device.
- b) An unlicensed U-NII Client device shall stop all its transmissions whenever instructed by a Master device to which it is associated. The device shall not resume any transmissions until it has again received enabling signals from a Master device.

- c) An unlicensed U-NII Client device that incorporates a Radar Interference Detection function shall inform the Master device and stop its networks transmission if it detects a radar.

The Master device may implement the Radar Interference Detection function referred to under a) using another device Associated with the Master. In such a case, the combination should be tested against the requirements applicable to the Master.

### **Applicability**

In Tables 1 and 2 shown below, the applicability of DFS requirements prior to use of a channel (*Channel Availability Check*) and during normal operation (*In-Service Monitoring*) for each of the above mentioned operational modes.

The manufacturer shall state whether the UUT is capable of operating as a Master and/or as a Client. If the UUT is capable of operating in more than one operating mode then each operating mode shall be tested separately.

**Table 1: Applicability of DFS requirements prior to use of a channel**

Requirement	Operational Mode		
	Master	Client (without radar detection)	Client (with radar detection)
Non –occupancy period (required for band 5600- 5650 MHz)	✓	Not required	✓
Interference Detection Threshold	✓	Not required	✓
Channel Availability Check Time	✓	Not required	Not required
Uniform Spreading	✓	Not required	Not required

**Table 2: Applicability of DFS requirements during normal operation**

Requirement	Operational Mode		
	Master	Client (without radar detection)	Client (with radar detection)
Interference Detection Threshold	✓	Not required	✓
Channel Closing Transmission Time	✓	✓	✓
Channel Move Time	✓	✓	✓

**Detection Threshold values**

The following tables give the DFS thresholds for Master devices and for Client devices.

**Table 3A: Interference Threshold values, Master**

Maximum Transmit Power	Value (see note)
≥200 mW	-64 dBm
<200 mW	-62 dBm
Note: This is the level at the input of the receiver assuming a 0 dBi receive antenna	

**Table 3B: Interference Threshold values, Client with Radar Detection**

Maximum Transmit Power	Value
$\geq 200$ mW	-64 dBm
$< 200$ mW	-62 dBm
Note: This is the level at the input of the receiver assuming a 0 dBi receive antenna	

### Response Requirements

The following table gives the response requirements for DFS implementation.

**Table 4: DFS Response requirement values**

Parameter	Value
Non-occupancy period	30 minutes
Channel Availability Check Time	60 s
Channel Move Time	10 s
Channel Closing Transmission Time	260 ms

## Testing for Compliance with Technical Requirements

### Radar Test Signals

The DFS test signals shown in Table 5 shall be used.

**Table 5: Parameters of DFS test signals**

Radar test signal	Pulse repetition frequency PRF [pps]	Pulse width W [ $\mu$ s]	Burst length L [ms] / No. of pulses (Note 1)	Burst Period B [sec] (Note 2)	Hopping Rate (Note 4)
Fixed Frequency Radar signal 1	700	1	26 / 18	10	Na
Fixed Frequency Radar signal 2	1800	1	5 / 10	2	Na
Frequency Hopping Radar	3000	1	100/300	10	1 kHz

Note 1: This represents the number of pulses seen at the unit under test (UUT) per radar scan  $N = [\{\text{antenna beamwidth (deg)}\} \times \{\text{pulse repetition rate (pps)}\}] / [\{\text{scan rate (deg/s)}\}]$

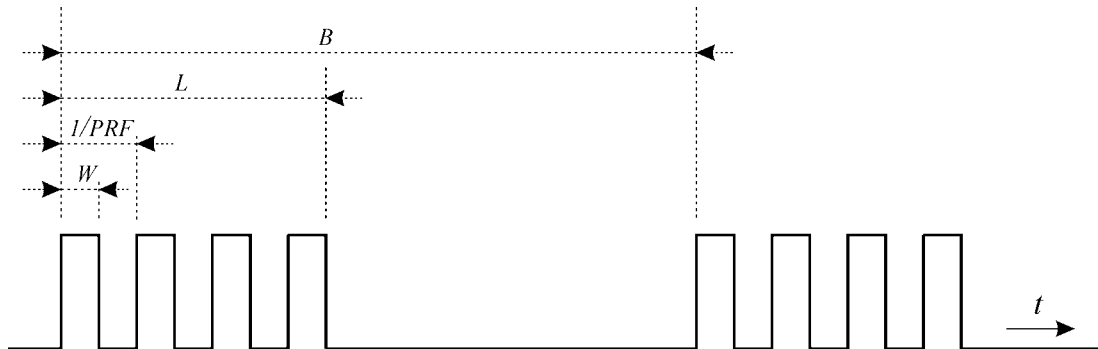


Note 2: Burst period represents the time between successive scans of the radar beam  
 $B = 360 / \{\text{scan rate (deg/s)}\}$

Note 3: Radar bandwidth is less than that of the unlicensed U-NII device.

Note 4: The characteristics of this frequency hopping radar do not correspond to any specific system. It can hop across the 5250-5725 MHz band. The frequencies will be selected by using a random without replacement algorithm until all 475 frequencies have been used. After all have been used, the pattern is reset and a new random set is generated.

**Figure 1: General structure of the DFS test transmission sequences**



## Test Procedures

### DFS Testing

#### Conducted Test conditions

The conformance requirements given in the section on Technical Requirements for DFS shall be verified under normal operating conditions, and in each of the stated frequency range(s), and with each of the applicable radar signals defined in Table 5.

For a UUT with antenna connector(s) and using external antenna(s), or for a UUT with integral antenna(s) but with a temporary antenna connector provided, conducted measurements shall be used. In this case, and if the UUT has a Radar Interference Detection Function, the output power of the signal generator producing the radar test signals shall provide a received signal power at the antenna connector of the UUT with a level equal to (*Interference Detection Threshold* + G), see Tables 3A and 3B. Parameter G [dBi] corresponds to the gain of the antenna assembly stated by the manufacturer. If more than one antenna assembly is intended, the gain of the antenna assembly with the lowest gain shall be used.

For a UUT with integral antenna(s) and without temporary antenna connector, radiated measurements shall be used. In this case, and if the UUT has a Radar Interference Detection Function, the output power of the signal generator shall provide a signal power at the antenna with a level equal to *Interference Detection Threshold*.

Some of the tests may be performed more readily if a test mode for a Master device is provided that overrides the channel selection mechanism for the uniform spreading requirement to allow a specific channel to be set for startup. In this mode it is preferable that the Master will continue operation normally upon starting (i.e. perform channel availability check on the chosen channel and begin normal operation if no radar is detected – or respond normally if a radar is detected during the channel availability check or in-service monitoring on the chosen channel

Some of the tests may be performed more readily if the channel selection mechanism for the uniform spreading requirement can be disabled, for example, to ensure selection of a channel outside the 5150-5250 MHz and 5725-5825 MHz bands.

However, this mode of operation is not required to successfully complete the testing.

Atheros: Need for special test modes should not be made a mandatory feature in order to complete testing. However, the availability of the above suggested test mode will expedite testing.

This test mode is also used for radar detect testing per the ETSI spec and results in minimal tinkering with the device's normal operation. This test mode is likely to already be available in current devices and would be needed to satisfy the desired operation described under the section 'Unlicensed U-NII Device Initialization' which states: "One channel, outside the 5150-5250 MHz and 5725-5825 MHz range, is selected from the stated operating frequency range(s) of the UUT..."

It should be noted that once a UUT is powered on, it will not start its normal operating functions immediately, as it will have to finish its power-up cycle first ( $T_{\text{power\_up}}$ ). As such, the UUT, as well as any other device used in the set-up, may be equipped with a feature that will indicate its status during the testing, including, for example, power-up mode, normal operation mode, channel check status and radar detection event.

### **Conducted Test Configurations**

The sections below contain simplified block diagrams that focus on the radar signal injection path for each of the different conducted set-ups to be used. The basic set-up is identical for all cases. Full details of this setup, including calibration, can be found in Annex B to this document.

### ***Test of the DFS functions of the Master***

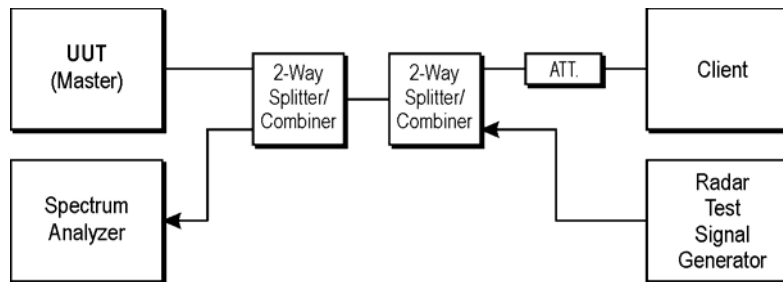
#### **Set-up A: Master with injection at the Master**

When the UUT is an unlicensed device operating as a Master, the test set-up, further referred to as ‘*Set-up A*’ shall be used.

‘*Set-up A*’ consists of a signal generator connected to the UUT and an unlicensed device operating as a Client. The latter is assumed to Associate with the UUT (Master).

Figure 2 shows a block diagram for ‘*Set-up A*.’

**Figure 2: Conducted Set-Up where UUT is a Master and Radar Test Signals are injected into the Master**



### ***Test of DFS functions of the Client***

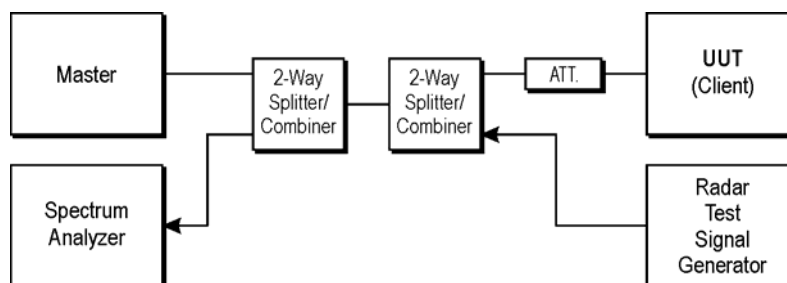
#### **Set-up B: Client with injection at the Master**

When the UUT is an unlicensed device operating as a Client, with or without a Radar Interference Detection Function (RIDF), the test set-up, further referred to as ‘*Set-up B*’ shall be used.

‘*Set-up B*’ consists of a signal generator connected to a unlicensed device operating as a Master and the UUT. The latter is assumed to Associate with the Master.

Figure 3 shows an example for ‘*Set-up B*.’ The set-up used shall be documented in the test report.

**Figure 3: Conducted Set-Up B where UUT is a Client and Radar Test Signals are injected into the Master**

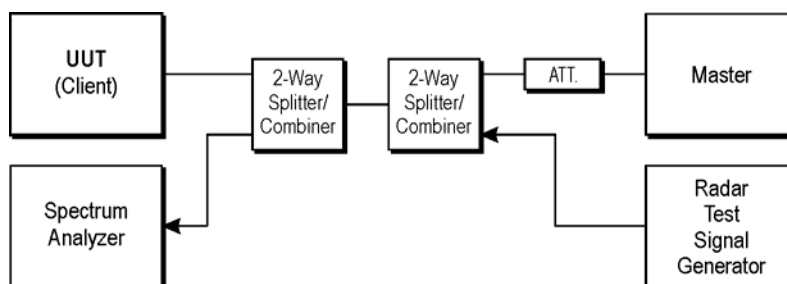


Set-up C: Client with injection at the Client

When the UUT is an unlicensed device operating as a Client with a Radar Interference Detection Function (RIDF), the tests described in the section on Test of DFS Function of the Client need to be repeated using a set-up, further referred to as ‘Set-up C.’

‘Set-up C’ consists of a signal generator connected to the UUT (Client). Figure 4 shows an example for ‘Set-up C.’

**Figure 4: Conducted Set-Up C - where UUT is a Client and Radar Test Signals are injected into the Client**



For the purposes of the test, the UUT as well as other unlicensed U-NII devices used in the set-up may be equipped with a specific user interface to allow monitoring of the behavior of the different devices of the set-up during the tests.

The UUT is capable of transmitting a test transmission sequence. The signal generator is capable of generating any of the radar test signals defined in Table 5. Adequate measurement equipment, e.g., spectrum analyzer, shall be used to measure the aggregate transmission time of the UUT.

### Radiated Test conditions

The conformance requirements given in the section on Technical Requirements for DFS shall be verified under normal operating conditions, and in each of the stated frequency range(s), and with each of the applicable radar signals defined in Table 5. However, if the UUT is a Slave

without radar detection, only one of the radar signals should be chosen and used for testing..

Atheros: Slave without radar detection does not need repeat testing with all 3 radar types since the Master device acts as support equipment and is assumed to be capable of detecting any of the 3 radars and the Master is not being tested for its ability to detect all radar types. When UUT is a Slave without radar detection, this test simply checks that it responds to the Master's silencing command and silences within the prescribed time limit. Therefore there is no need to increase test time for this type of UUT by repeating this test 3 times.

For a UUT with integral antenna(s) and without temporary antenna connector, radiated measurements shall be used. In this case, and if the UUT has a Radar Interference Detection Function, the output power of the signal generator shall provide a signal power at the antenna with a level equal to *Interference Detection Threshold*.

Some of the tests may be performed more readily if a test mode for a Master device is provided that overrides the channel selection mechanism for the uniform spreading requirement to allow a specific channel to be set for startup. In this mode it is preferable that the Master will continue operation normally upon starting (i.e. perform channel availability check on the chosen channel and begin normal operation if no radar is detected – or respond normally if a radar is detected during the channel availability check or in-service monitoring on the chosen channel can be disabled, for example, to ensure selection of a channel outside the 5150-5250 MHz and 5725-5825 MHz bands.

However, this mode of operation is not required to successfully complete the testing.

It should be noted that once a UUT is powered on, it will not start its normal operating functions immediately, as it will have to finish its power-up cycle first ( $T_{\text{power\_up}}$ ). As such, the UUT, as well as any other device used in the set-up, may be equipped with a feature that will indicate its status during the testing, including, for example, power-up mode, normal operation mode, channel check status and radar detection event.

### **Radiated Test Configurations**

The sections below contain simplified block diagrams that focus on the radar signal injection path for each of the different radiated set-ups to be used. The basic set-up is identical for all cases. Full details of this setup, including calibration, can be found in Annex C to this document.

### ***Test of the DFS functions of the Master***

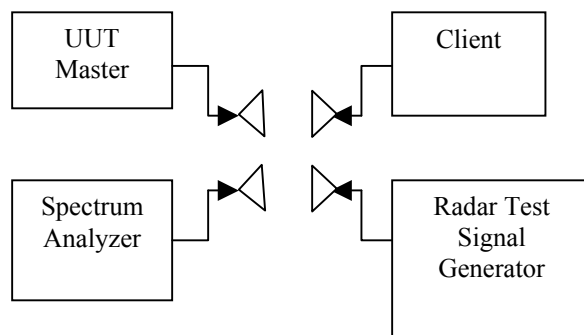
Set-up A: Master with injection at the Master

When the UUT is an unlicensed U-NII device operating as a Master, the test set-up, further referred to as '*Set-up A*' shall be used.

'*Set-up A*' consists of a signal generator connected to the UUT and an unlicensed U-NII device operating as a Client. The latter is assumed to be associated with the UUT (Master).

Figure 5 shows a block diagram for '*Set-up A*.'

**Figure 5: Radiated Set-Up where UUT is a Master and Radar Test Signals are injected into the Master**



### ***Test of DFS functions of the Client***

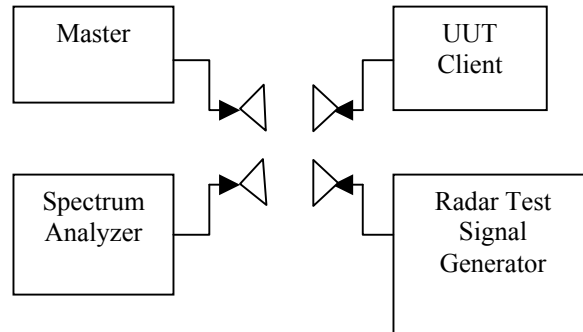
Set-up B: Client with injection at the Master

When the UUT is an unlicensed U-NII device operating as a Client, with or without a RIDF, the test set-up, further referred to as '*Set-up B*' shall be used.

'*Set-up B*' consists of a signal generator connected to an unlicensed U-NII device operating as a Master and the UUT. The latter is assumed to be associated with the Master.

Figure 6 shows an example for '*Set-up B*.' The set-up used shall be documented in the test report.

**Figure 6: Radiated Set-Up B where UUT is a Client and Radar Test Signals are injected into the Master**

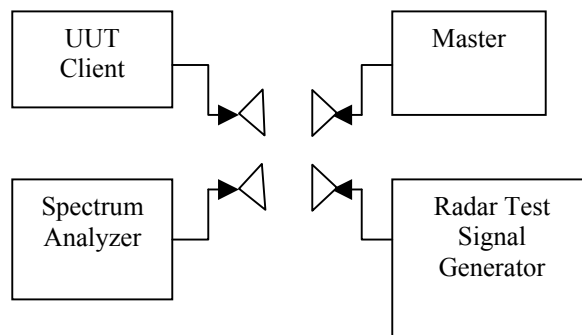


#### Set-up C: Client with injection at the Client

When the UUT is an unlicensed U-NII device operating as a Client with a RIDF, the tests described in Test of DFS Functions as the Client need to be repeated using a set-up, further referred to as ‘*Set-up C.*’

‘*Set-up C*’ consists of a signal generator connected to the UUT (Client). Figure 7 shows an example for ‘*Set-up C.*’

**Figure 7: Radiated Set-Up C - where UUT is a Client and Radar Test Signals are injected into the Client**



For the purposes of the test, the UUT as well as other unlicensed U-NII devices used in the set-up may be equipped with a specific user interface to allow monitoring of the behavior of the different devices of the set-up during the tests.

The UUT is capable of transmitting a test transmission sequence. The signal generator is capable of generating any of the radar test signals defined in Table 5.

Adequate measurement equipment, *e.g.*, spectrum analyzer, shall be used to measure the aggregate transmission time of the UUT.

## **Radar Signal Generation and Calibration**

Detailed set-up and instructions for calibration are given in Annexes B and C.

## **Unlicensed U-NII device initialization**

This section describes the verification procedure for the Channel Availability Check to be performed at initialization of an unlicensed U-NII device. See section on DFS overview.

One channel, outside the 5150-5250 MHz and 5725-5825 MHz range, is selected from the stated operating frequency range(s) of the UUT. This channel is designated as  $Ch_r$  (channel occupied by a radar).

The UUT shall be configured to select  $Ch_r$  as the first operating channel.

$T_{ch\_avail\_check}$  is the minimum Channel Availability Check Time as specified in Table 4.

The different steps below define the procedure to verify the response behavior parameters when a radar burst is generated on the selected channel at the beginning or at the end of the Channel Availability Check Time.

### ***Radar burst at the beginning of the Channel Availability Check Time***

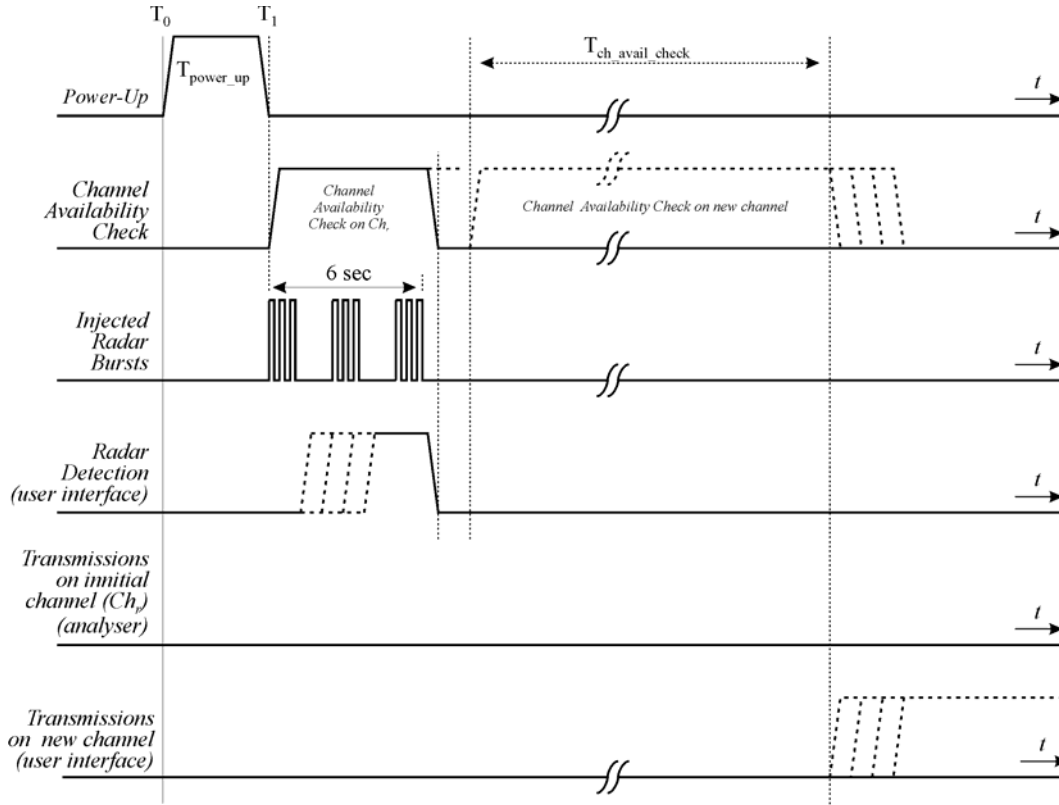
The steps below define the procedure to verify successful radar detection on the selected channel during a period equal to the *Channel Availability Check Time* and avoidance of operation on that channel when a radar burst with a level equal to the *Interference Detection Threshold* occurs at the beginning of the Channel Availability Check Time.

- a) The signal generator and UUT are connected using the applicable test set-ups described in section on Conducted Tests and the power of the UUT is switched off.
- b) The UUT is powered on at  $T_0$ .  $T_1$  denotes the instant when the UUT has completed its power-up sequence ( $T_{power\_up}$ ). The channel availability check is expected to commence on  $Ch_r$  at instant  $T_1$  and is expected to end no sooner than  $T_1 + T_{ch\_avail\_check}$  unless a radar is detected sooner.
- c) Radar bursts are generated on  $Ch_r$  using one of the test patterns defined in Table 5. Radar bursts should commence at time  $T_1$  and should continue for approximately 6 seconds.
- d) Visual indication on the UUT of successful detection of the radar burst (if indication is available) should be recorded. Observation of  $Ch_r$  shall continue until the UUT starts transmitting on another channel. (*In the example given below, the UUT performs a channel availability check on a new channel after it has detected a radar on  $Ch_r$ .*) It shall be verified and recorded that during the above steps no transmissions occurred on  $Ch_r$ .



- e) A timing trace or description of the observed timing and behavior of the UUT should be reported.

**Figure 8: Example of timing for radar testing at the beginning of the Channel Availability Check Time**



### ***Radar burst at the end of the Channel Availability Check Time***

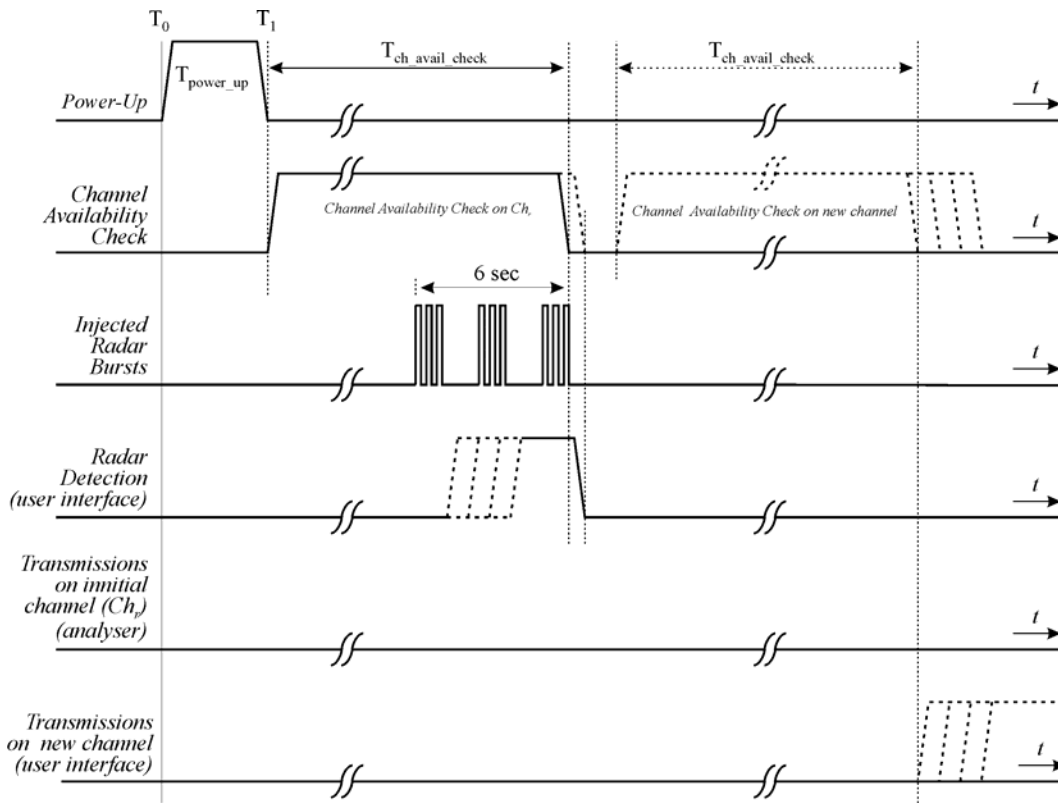
The steps below define the procedure to verify successful radar detection on the selected channel during a period equal to the *Channel Availability Check Time* and avoidance of operation on that channel when a radar burst with a level equal to the *Interference Detection Threshold* occurs at the end of the Channel Availability Check Time.

- The signal generator and UUT are connected using the applicable test set-ups referred to in section on Conducted Test Configurations and the power of the UUT is switched off.
- The UUT is powered up at  $T_0$ .  $T_1$  denotes the instant when the UUT has completed its power-up sequence ( $T_{\text{power\_up}}$ ). The channel availability check is expected to commence on  $Ch_r$  at instant  $T_1$  and is expected to end no sooner than  $T_1 + T_{\text{ch\_avail\_check}}$  unless a radar is detected sooner.
- Radar bursts are generated on  $Ch_r$  using one of the test patterns defined in [Table 5 section 5.1](#) at a level defined in the DFS Overview section. Radar bursts should

commence near the end of the minimum required Channel Availability Check Time at time  $T_1 + T_{ch\_avail\_check} - 6 \text{ [sec]}$  and should continue for the duration of this test.

- d) Visual indication on the UUT of successful detection of the radar burst (if indication is available) should be recorded. Observation of  $Ch_r$  shall continue until the UUT starts transmitting on another channel. *(In the example given below, the UUT performs a channel availability check on a new channel after it has detected a radar on  $Ch_r$ ).* It shall be verified and recorded that during the above steps no transmissions occurred on  $Ch_r$ .
- e) A timing trace or description of the observed timing and behavior of the UUT should be recorded.

**Figure 9: Example of timing for radar testing towards the end of the Channel Availability Check Time**



### In-Service Monitoring

These tests define how the following DFS parameters can be verified during In-Service Monitoring

- Interference Detection Threshold
- Channel Closing Transmission Time

- Channel Move Time
- Non-Occupancy Period

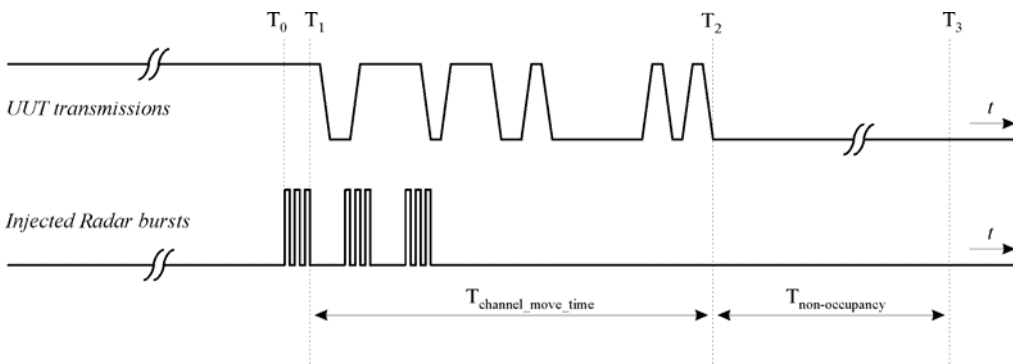
The steps below define the procedure to determine the above mentioned parameters when a radar burst with a level equal to the *Interference Detection Threshold* is generated on the channel of operation of the unlicensed U-NII device (*In- Service Monitoring*).

- a) A channel outside 5150-5250 MHz and 5725-5825 MHz bands is selected from the stated operating frequency range(s).
- b) In case the UUT is an unlicensed U-NII device operating as a Client (with or without Radar Interference Detection Function), an unlicensed U-NII device operating as a Master will be used to allow the UUT to associate with the Master. In case the UUT is a Master, an unlicensed U-NII device operating as a Client will be used and it is assumed that the Client will associate with the UUT (Master). In both cases, the signal generator shall be connected to the Master.
- c) The UUT transmits a test transmission sequence on the selected channel.
- d) At a certain time T0 the signal generator starts generating one of the radar test patterns defined in Table 5 at a level defined in the section on Response Requirements on the selected channel. T1 denotes the end of the first radar burst.
- e) The transmissions of the UUT following instant T1 on the selected channel shall be observed for a duration of at least 10 seconds. The aggregate duration of all transmissions from the UUT during the observation time (*Channel Closing Transmission Time*) shall be noted and compared to the limit defined in Table 4. Note: the aggregate duration of all transmissions of the UUT does not include quiet periods in between transmissions of the UUT.
- f) T2 denotes the instant when the UUT has ceased all transmissions on the channel. The time difference between T1 and T2 shall be measured. This value (*Channel Move Time*) shall be noted and compared with the limit defined in Table 4.
- g) When the UUT is an unlicensed U-NII device operating as a Master, following instant T2, the selected channel per Table 1 shall be monitored for an additional 30 minutes (*Non-Occupancy Period*) until instant T3, to verify that the UUT does not resume any transmissions on this channel.

**Atheros: Table 1 further clarifies the Non-Occupancy requirement so should be referenced here.**

- h) The test shall be repeated using each of the radar signals defined in ~~the section on Testing for Compliance with Technical Requirements;~~ Table 5.
- i) In case the UUT is an unlicensed U-NII device operating as a Client with a Radar Interference Detection Function, the steps a) to h) shall be repeated with the generator connected to the UUT.

**Figure 10: Channel Closing Transmission Time & Channel Clearing Time**



## Annex A

### General Requirements

#### ***Product information***

The following information shall be stated by the manufacturer in order to facilitate the execution of the test suites:

- a) the operating frequency range(s) of the equipment;
- b) the operating modes (Master and/or Client)
- c) the highest and the lowest possible power level (equivalent isotropically radiated power (EIRP)) of the equipment;
- d) the intended antenna assemblies and their corresponding gains;
- e) the test sequences or messages used for communication between Master and Client devices.

#### ***Interpretation of the measurement results***

The interpretation of the results recorded in a test report for the measurements described in the present document shall be as follows:

- the measured value related to the corresponding limit will be used to decide whether an equipment meets the requirements of the present document;
- the value of the measurement uncertainty for the measurement of each parameter shall be included in the test report;
- the recorded value of the measurement uncertainty shall be, for each measurement, equal to or lower than the figures in Table A.1;
- the shared risk approach shall be applied for the interpreting of all measurement results.

**Table A.1: Maximum measurement uncertainty**

Parameter	Uncertainty
RF frequency	$\pm 1 \times 10^{-5}$
RF power conducted	$\pm 1.5$ dB
RF power radiated	$\pm 2$ dB
Spurious emissions, conducted	$\pm 3$ dB
Spurious emissions, radiated	$\pm 2$ dB
Time	$\pm 5$ %

## Channel Loading

The data test file that is used for transmissions to/from the master and the client should be constructed so that the data packets are representative of the weighting factors shown in Table A2 for packet size. A single data rate will be chosen for testing, normally the highest supported rate for the UUT, and data rate (Annex 4 Table 4 of Recommendation ITU-R M. 1652).

Atheros: It is not feasible to perform testing with the UUT changing between data rates per the weighting table above. An RLAN operates at the best possible rate depending upon the received signal. Therefore, this rate will not vary during lab testing. The M.1652 tables represents simulated "Aggregate" RLAN activity (e.g. some RLANs operating at 6Mbps, some at 54Mbps, etc.). This cannot be done for the "single" RLAN under test. The highest data rate should be set for all testing.

Table A2  
Weighting of data test file

Packet size (bytes)	Weight	Data-rate (Mbit/s)	Weight
64	0.6	6	0.1
538	0.2	12	0.1
1 500	0.2	18	0.1
		24	0.3
		36	0.3
		54	0.1

Atheros: Packet sizes chosen by the RLAN MAC can be manipulated to some degree (ie. limit upper size), but cannot be easily manipulated to simulate a mix of packet lengths as suggested above. Therefore, an agreed file generation technique (not a large "test file") should be used. Rather than distributing a multi-megabyte file, a streaming data technique (such as a .WAV file & media player) can easily be replicated by any test lab. A trace of the resulting traffic pattern can be included in test reports. A complete set of

proposed instructions to generate such a file was  
provided to the government/industry group previously.

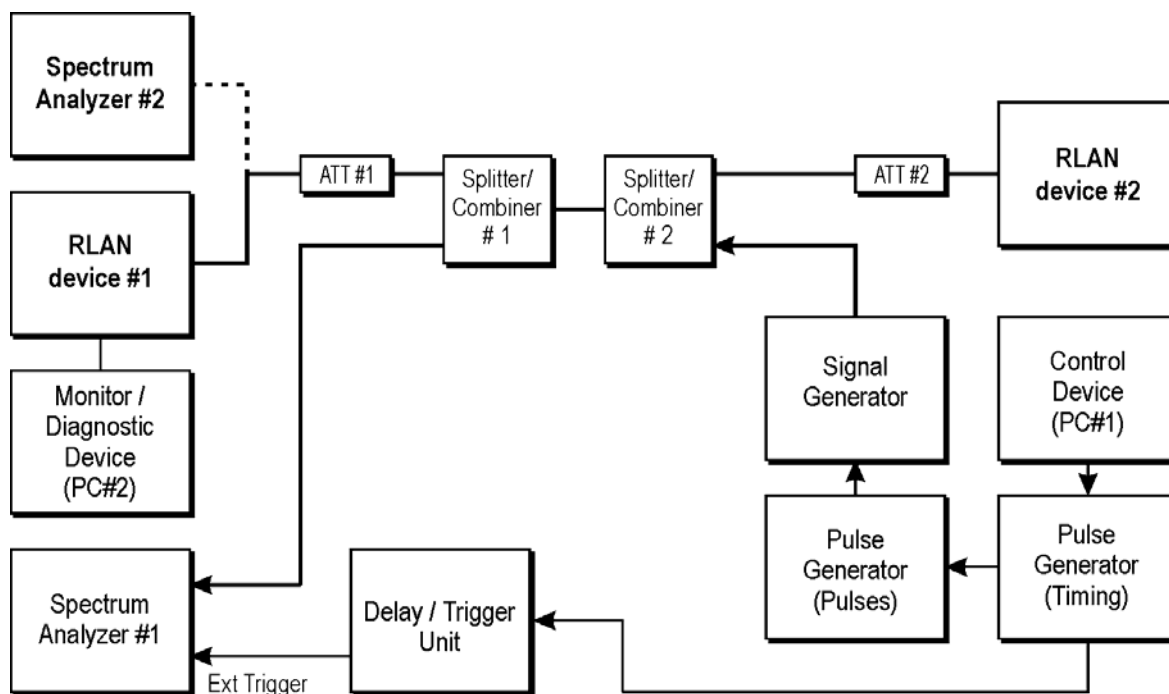
## Annex B

### Conducted Test Set-up and Calibration

#### *Block Diagram*

Conducted measurements are the preferred method to perform these tests. In this method, cables are used to supply the unlicensed U-NII device signals to/from the devices under test and the test equipment. Equipment with an integral antenna may be equipped with a temporary antenna connector in order to facilitate the conducted tests. Figure B1 shows a detailed set-up for performing conducted measurements.

**Figure B1: Conducted DFS Measurements - Test Set-Up**



It is important to note that the Signal Generator used should have the ‘Short Pulse’ option to guarantee that the Automatic Level Control circuitry can also deal with short pulses (this will be verified during the calibration part.). It might be possible that the function of the Delay/Trigger unit is part of the features of Spectrum Analyzer #1.

The value of the attenuator #1 and attenuator #2 are chosen in such a way that the received unlicensed U-NII signal (unlicensed U-NII device #2) at the input of the UUT (unlicensed U-NII device #1) is minimum about 20 dB above the threshold level to be tested (the received unlicensed U-NII device signal should be much stronger as the radar test signals).



The duty cycle of the unlicensed U-NII device transmissions should be sufficiently high. Also the duration of the unlicensed U-NII device transmissions should be sufficiently high to allow the measurements to be repeated a number of times (e.g., 10 times). ~~In order to allow some of the tests to be repeated on the same channel, it may be required for the diagnostic software to disable the 'move to a new channel feature' after a radar pulse was detected the first time, otherwise the whole set up need to be re-calibrated on the new frequency.~~

**Atheros: This additional test mode is not necessary since repeat detect testing on a chosen channel can be easily achieved using the suggested test mode proposed previously in these comments (i.e. to disable the uniform spreading feature at startup so operation commences on a chosen channel).**

### ***Calibration procedure***

- 1) During this calibration, there are no transmissions initiated by the UUT.
- 2) For calibrating the test set-up (exact threshold level at the UUT, unlicensed device #1), the UUT is replaced by a Spectrum Analyzer with an accurate power level measurement feature.
- 3) The Spectrum Analyzer #2 is switched to 'Zero Span' mode and to the 'Time Domain' mode and it shall be verified if the level of each of the Radar pulses is identical. This is required to verify the proper functioning of ALC circuit of the Signal Generator for short pulses. For each of the tests (different radar test signals), the level of the Signal Generator is adjusted until the appropriate level (e.g. -62 dBm) is measured by the Spectrum Analyzer #2.
- 4) The Spectrum Analyzer #1 is switched to 'Zero Span' mode and to the 'Time Domain' mode with an adaptive sweep time. The time base of the Spectrum Analyzer is externally triggered by the Pulse Generator through a delay circuit so that the sweep is already started a few ms before the first pulse of the Signal Generator appears. This will bring the radar burst clearly within the view window of the analyzer.
- 5) A reference point, indicating the start of the first pulse of the radar test signal (often equal to the time of the external trigger) should be set (marker T1) before any UUT transmissions are initiated.
- 6) The Radar Test Signal is switched off.

### ***Taking Measurements***

- The Monitor/Diagnostic Device (PC#2) starts transmissions between the 2 unlicensed U-NII devices.
- The Control Device #2 will switch on the Radar Test Signal at the instances indicated in the procedures in section 5

- The screen will now show the behavior of the unlicensed U-NII devices to the Radar Test Signal.

Note: it should be possible, with the above described set-up, to distinguish (on the spectrum analyzer screen) (1) the Radar Test Signals, (2) U-NII signals.

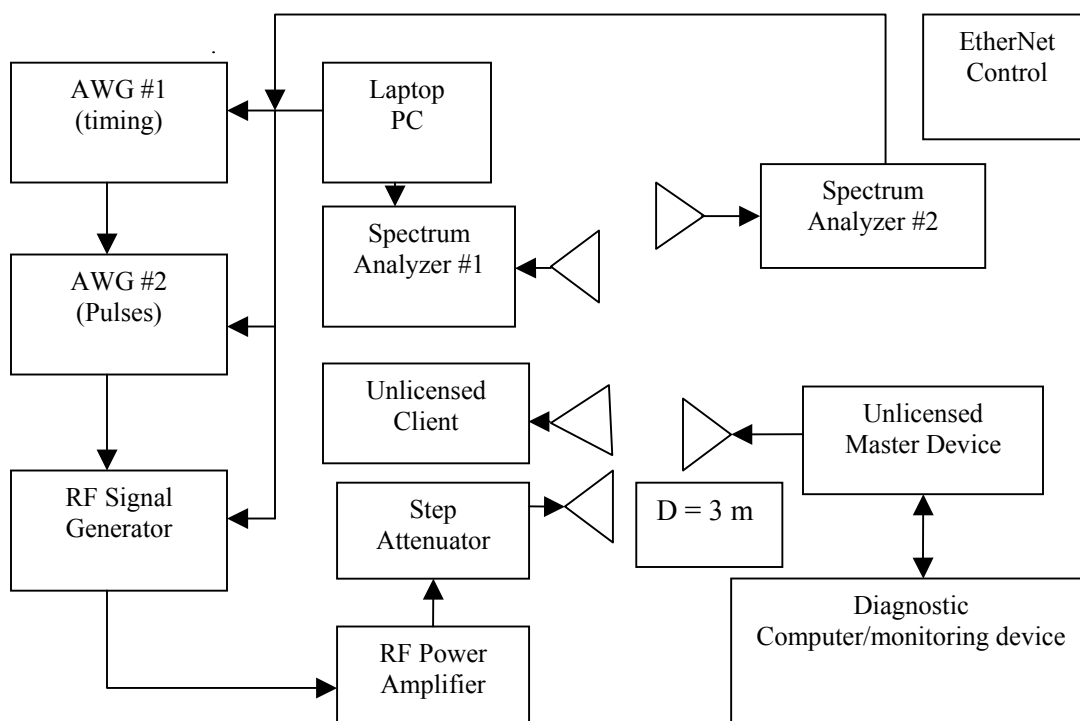
## Annex C

### Radiated Test Set-up and Calibration

#### Block Diagram

Radiated tests may be performed when the antenna of the unlicensed U-NII device is integral (i.e., the antenna cannot be separated from the device) and an external antenna port is not provided. Figure C1 shows a detailed set-up for performing the radiated test measurements.

Figure C-1.



#### Calibration procedure

During this calibration, there are no transmissions initiated by the UUT.

- 1) For calibrating the test set-up (exact threshold level at the UUT) Spectrum analyzer #2 will be used to measure the power output of the radar signal simulator for each type of signal in Table 5.
- 2) Spectrum Analyzer #2 will be set to zero span mode with the RMS detector at the frequency of the chosen unlicensed device channel. The resolution and video bandwidth will be set to 1 MHz. The unlicensed device integration time as defined by the ITU is 1 microsecond. In order to achieve this integration time, the sweep time of the analyzer must be set appropriately as follows. If the analyzer has 1000 points or “bins” across its display, the sweep time is equal to that number multiplied by 1 microsecond, or 1 millisecond. For 8000 points (the maximum on the Agilent E440 analyzer) the sweep time would be set to 8 milliseconds.
- 3) The radar signal generator will be turned on (for each radar type) and be allowed to “free run.” The pulses will be constantly on and not generated in bursts. Note that the frequency hopping radar will be set to a fixed frequency.
- 4) The step attenuator will be used to adjust the power level at Spectrum Analyzer #2 to the level that is required for the tests.  
  
This value must be adjusted for the gain of the horn antenna connected to the analyzer and adjusted once again if the antenna on the unlicensed U-NNII device has gain.  
The techniques for measuring pulsed emissions from radars can be found in ITU-R M.1177-2.
- 5) After the attenuator has been adjusted to achieve the proper power level the RF output of the simulator will be turned off.

## **Taking Measurements**

### **Fixed Frequency Radar Simulator**

- 1) The power level (-64, -62, -55 dBm) of the radar signal will be calibrated for the appropriate radar signal type in Table 5 at the antenna of the unlicensed U-NII device. The higher power level (-55 dBm) will be used to test the DFS functionality of the unlicensed device before the ITU detection thresholds are tested.
- 2) The unlicensed U-NII devices will be turned on and be instructed to operate on the appropriate unlicensed U-NII channel that must incorporate DFS functions. Attenuators or some type of power control will be used to set the power of the unlicensed link [to be determined] dB above the radar simulator power.
- 3) The radar simulator will be turned on and emulate one of the two fixed frequency radars in Table 5 with the appropriate parameters (pulsewidth, burst length, and burst period).
- 4) Spectrum analyzer #1 and a diagnostic computer/monitor will be used to monitor the output of the unit under test (UUT) to observe that its behavior is consistent with the channel occupancy and move times of ITU-R M.1652.
- 5) If the UUT does not properly detect the simulated radar pulses in [to be determined] minutes the device will not pass the test.

Note that both types of Fixed frequency radars from Table 5 will be tested.

### **Frequency Hopping Radar Simulator**

- 1) The power level (-64, -62, -55 dBm) of the radar signal will be calibrated for the frequency hopping radar signal type in Table 5 at the antenna of the unlicensed U-NII device. The higher power level (-55 dBm) will be used to test the DFS functionality of the unlicensed device before the ITU detection thresholds are tested.
- 2) The unlicensed U-NII devices will be turned on and be instructed to operate on the appropriate U-NII channel that must incorporate DFS functions. Attenuators or some type of power control will be used to set the power of the unlicensed link [to be determined] db above the radar simulator power.
- 3) The radar simulator will be turned on and emulate the frequency hopping radar in Table 5 with the appropriate parameters (pulsewidth, burst length, burst period, and hopping rate).
- 4) Spectrum analyzer #1 and a diagnostic computer/monitor will be used to monitor the output of the unit under test (UUT) to observe that its behavior is consistent with the channel occupancy and move times of ITU-R M.1652.
- 5) The UUT will be monitored for [to be determined] minutes to determine if it can detect the frequency hopping radar.